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Temporary Sequestration Credits:

An Instrument for Carbon Bears

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Abstract

Temporary crediting of carbon storage is a proposed instrument that allows entities with emissions reductions obligations to defer some obligations for a fixed period of time. This instrument provides a means of guaranteeing the environmental integrity of a carbon sequestration project. But because the user of the temporary credit takes on the liability of renewing it, or replacing it with a permanent credit, the temporary credit must sell at a discount compared to a permanent credit. We show that this discount depends on the expected change in price of a permanent credit. Temporary credits have value only if restrictions on carbon emissions are not expected to tighten substantially. The intuition is illustrated by assessing the value of a hypothetical temporary sulfur dioxide sequestration credit, using historical data on actual SO2 allowance prices.

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1. Introduction

Carbon sequestration projects—such as plantations, agroforestry, improved agricultural techniques, or geological sequestration—offer potentially cost-effective ways of removing CO_2 from the atmosphere, or of keeping it out of the atmosphere in the first place.

But unlike abatement in the energy sector, each such project faces some risk of reversal. Forests and fruit trees can burn. Geological formations can leak. Soil carbon can be released if exposed. The risk of non-permanence has inspired a search for means of insuring the integrity of carbon credits based on sequestration projects (Watson et *al.*, 2000). One frequently discussed option is to provide for temporary crediting of carbon storage (UNFCCC, 2000, Sedjo and Marland, 2003, Locatelli and Pedroni, 2003). A project proponent would guarantee carbon sequestration for, say, five years, or from one Kyoto commitment period to the next. At the end of that period, the temporary credit expires. The holder suffers a debit on his carbon account, which he can make up for securing a reduction based on an energy project, by retiring an emissions allowance from the second commitment period, or by renewing the temporary credit if the sequestration project is still ongoing.

This approach has two strong advantages. Environmental integrity is guaranteed without requiring perpetual maintenance and monitoring of a sink. And options are preserved for host countries, who need not commit to maintaining a forest in perpetuity.

But do temporary credits make economic sense? The purchaser of a temporary credit takes on a liability: the necessity to find a follow-on credit. Under what conditions would anyone want to assume such a liability? Because temporary credits carry this liability, they are bound to sell at a discount compared to "permanent" emissions reductions from energy projects. Who will want to sell them?

The plan of the paper is as follows. First we discuss the equilibrium price of temporary credits, in the absence and presence of futures markets. These analyses provide a rough picture of the potential price differential between a permanent and temporary credit—a differential we argue might be substantial. We then assess the implications of this differential for the supply of temporary credits. Finally we discuss alternative mechanisms to assure permanence of sequestration.

2. Price of Temporary Credits

We assume an active market for 2008-2012 period carbon credits. That market can stem from entry into force of the Kyoto Protocol, or from other similar regulations such as trading within the E.U.

2.1. With Futures Markets and Advanced Purchase Requirement

We start by assuming that there is also a market for credits to be delivered in the second commitment period (2013-2017). ("Distant" futures markets such as this occur in the SO_2 allowance market.) We assume also that national authorities or international agreements allow the use of a temporary credit for the first commitment period only in conjunction with current purchase of a permanent second period credit. This assures the integrity of the emission reduction that is initiated with the temporary credit[2].

Let $P_{s,t}$ be the price for delivery in commitment period s of a permanent credit that can be used in commitment period t. Let P_{temp} be the current (commitment period 1) price of a temporary carbon credit. Then a buyer with carbon obligations for the first commitment period could either buy a current permanent credit, or combine a temporary credit with the forward purchase of a second period permanent credit. At market equilibrium, ignoring transaction costs, the prices of these alternatives should be equal. Hence:

$$\text{Ptemp} + \text{P1,2} = \text{P1,1} \qquad (1)$$

[2] This provision – not a feature of current proposals -- is suggested as a means of insuring the global community against the bankruptcy of the temporary credit holder. An unexpected rise in the price of renewing or redeeming at temporary credit could in fact provoke bankruptcy and failure to honor the obligations to redeem the temporary credit. Renewability could however be accommodated by selling the second period credit and buying a third period credit at the time of renewal.

Thus:

$$P_{temp} = P_{1,1} - P_{1,2} \tag{2}$$

The magnitude of the right hand side of (2) depends on intertemporal shifts in supply and demand, and on whether or not borrowing is permitted. First, suppose that the allowance market is expected to tighten significantly between the current and future periods. This would be the case, for instance, if the total number of future allowances was expected to decrease, while business-as-usual emissions were expected to increase. Then the price of allowances would tend to rise more rapidly than the rate of interest. However, banking would allow arbitragers to buy and bank period 1 allowances and simultaneously sell futures contracts, thus driving $P_{1,1}$ up and $P_{2,2}$ down. Absent transactions costs, the price rise would be limited to the rate of interest at equilibrium, so that $P_{1,1} \approx P_{1,2}$, and thus $P_{temp} \approx 0$. Bailley (1998) notes that a small convenience yield might attach to holding an earlier permit, so that $P_{1,1}$ might be slightly greater than $P_{1,2}$. She notes that in pre 1998 SO_2 allowance markets, this differential was only about 3%.

Suppose, instead, that prices were expected to stay relatively constant across periods. This might be true, for instance, if the total number of allowances remained constant, while technological change shifted downwards the marginal abatement cost curve. If it were possible to borrow allowances from the future, then $P_{2,2}$ would be bid up, and the differential between $P_{1,1}$ and $P_{1,2}$ would again tend to vanish, so that again $P_{temp} \approx 0$.

However, in both the SO_2 and currently-structured carbon markets, borrowing is not allowed. Schennach (2000) shows that this can drive a significant wedge □ between $P_{1,1}$ and $P_{1,2}$, so that $P_{1,1} = P_{1,2} +$□. This wedge can be interpreted as the shadow cost associated with the inability to borrow allowances from the future. Since the temporary credit provides, in effect, a license to borrow from the future, $P_{temp} =$ □.

Consider a rough numerical example. Suppose that negotiations around second period emissions allocations result in an expected maintenance of the same real price of carbon, i.e. $P_{1,1} = E(P_{2,2})$. Then we expect, roughly, $P_{1,2} = \square\, E(P_{2,2})$, where $\square$ is a discount factor that may include risk. If the discount rate is 6% and the time between commitment periods is five years, then a temporary sequestration credit is worth about 25% of a permanent one.

This calculation, however, applies only to the first temporary credit placed on the market. As the supply of temporary credits increases, more borrowing takes place, the price differential $P_{1,1} - P_{1,2}$ decreases, and the market value of the temporary credits declines.

2.2. A Thought Experiment: What if There Were Temporary SO2 Credits?

To gain further insights into the potential price of temporary CO_2 credits, let us use as a model the existing market for SO_2 allowances in the U.S. U.S. utilities are allocated an annual quota of allowances. The U.S. EPA also auctions allowances both for the current vintage (year t) and for the future vintage (year t+7). The allowances are tradable and bankable, and futures markets exist. Utilities typically manage their allowances with a horizon of many years, and can utilize a sophisticated derivative market to manage risk. Available instruments include futures, swaps, and options.

In this context, let us suppose that there were a technology for temporary sulfur sequestration, and that utilities were allowed to use a temporary credit in the manner described in the previous section. That is, the utility could emit a ton of SO_2 today (year t) by holding a seven-year temporary sequestration credit together with an allowance for year t+7. What is the most that utilities would be willing to pay for temporary sequestration services?

Figure 1 shows the evolution of $P_{t,t}$ and $P_{t,t+7}$ over the period t=1995-2002, as recorded in the annual EPA auctions of spot and 7-year forward allowances. Until 1998, the gap between the current price of a current allowance and the current price of a future allowance was less than 6%. Hence there would have been essentially no demand for temporary sulfur sequestration, even if the supply cost was negligible. Starting in 1999, however, the gap begins to widen, and by 2002 it is a substantial (58%). Thus a hypothetical temporary sulfur sequestration allowance would have been virtually worthless before 1999, but valuable thereafter.

What caused this divergence? It appears to be associated with the advent of Phase II of the allowance program in 2000. That Phase reduced the total annual issuance of allowances, and increased the number of plants required to participate, compared to the earlier Phase. Hence before t=2000, spot prices valued allowances in the loose Phase I market, and future t+7 prices referred to a much tighter Phase II market. As in the first scenario above, $P_{t,t} \approx P_{t,t+7}$, a finding reported by Bailey (1998). However, by 2000, both spot and futures prices referred to a market with approximately constant supply and demand characteristics. This introduced the wedge foreseen by Schennach.

2.3. Without Futures Market or Advanced Purchase Requirement

Robust futures markets may not arise for a while, given uncertainties about second commitment period allowances (including which countries participate in the Kyoto framework and accept emissions limitations), and about the global economy. So let us now suppose that futures markets are absent. We suppose that private parties are permitted to use temporary sequestration credits towards their first period compliance requirements, and must post some kind of collateral to ensure that they will replace the temporary credit with a permanent one (Again this is necessary to ensure integrity of the reduction; else a bankrupt holder of a temporary credit might fail to make it whole.) Hence the holder of a temporary credit is taking on a risky liability: the price of a permanent credit may go up.

In the absence of price guidance from futures markets—and because banking volumes are not revealed till the end of the first commitment period, the amount of banking may be insufficient to moderate price rise.

Suppose, for instance, that the U.S. ratifies Kyoto late in the first commitment period, and that banking is indeed inadequate to reduce permit prices between the first and second period. It is conceivable that prices could increase tenfold between periods. This would lead to remorse among buyers who had declined to purchase a first-period permanent credit, opting instead for a temporary credit and a second-period permanent credit. On the other hand, if Kyoto collapsed entirely, then the purchaser of a temporary credit would probably end up benefiting. In short, the buyer will purchase a temporary credit only when:[3]

$$P_{temp} + \square \int P_{2,2}\, f(P_{2,2})\, dP_{2,2} < P_{1,1} \tag{3}$$

In this equation, f(.) is the (subjective) probability distribution of price $P_{2,2}$, and □ is now the buyer's personal discount factor. Some rough guesses at the probability of alternative outcomes suggests that, under these circumstances buyers would find temporary credits unattractive if they perceived even a small chance of a near-term price spike (scenarios f to i in Table 1). For buyers with high discount rates and a bearish view of future prices, temporary credits are somewhat more attractive (scenarios a, b or e in Table 1).

2.4. A Hedging Strategy in the Absence of Futures Markets

The last section tells us that the most likely ultimate buyer of a temporary sequestration credit is an entity, faced with current carbon liabilities, with a high discount rate and bearish views on the evolution of carbon prices. Complementing this buyer, and in the absence of a liquid futures market, there may exist sellers of future permanent reductions, who share the bearish view and the high discount rates. For instance, current installation of an energy-efficient building or of a low-emissions power plant may result in a stream of emissions reductions for decades to come. It may be possible to package these future reductions with current temporary credits in a way that provides a secure and price-competitive alternative to a current permanent reduction.

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[3] This equation is valid only when the cost of allowances at both periods are small compared to the revenue level of the buyer at first and second period (C_1 and C_2).

For instance, suppose that the current (2003) price of carbon is \$3/tonne. A real-estate developer seeks carbon revenue by redesigning a proposed office building for increased energy efficiency. The office building has a minimum expected life of 20 years and produces new permanent reductions each year relative to the baseline. To finance the building, the developer contracts to sell each year's reductions at \$3, through 2012, with payment on delivery. The developer may be happy to sell, in addition, post-2012 reductions for a current payment of \$0.75/tonne, reflecting pessimism on carbon prices and current investment opportunities offering high rates of return (say, 15%). After allowing another \$0.75/tonne for insurance and transactions costs, this might allow payment of up to \$1.50/tonne for a temporary credit. Of course, in the presence of thin markets, the division of gains between the seller of temporary credit and the real-estate developer would be subject to negotiation.

A further refinement might be to bundle temporary credits with call options to buy permanent emission reductions. This way, the buyer is insured both against the risk that the price of carbon at second period goes too high, in which case she can exercise the option and pay a pre-agreed strike price, and against the risk that the price of carbon becomes too low, in which case he or she can buy directly on the market without exercising the option.

These numbers are sheer guesswork, but are not entirely implausible. They suggest that a 'bundling' strategy may be a way to muster a non-negligible price for temporary credits while also financing carbon projects involving long-lived infrastructure.

3. Supply of Temporary Credits

Even under the "bundling" strategy described below, temporary sequestration credits may have to sell at a substantial discount compared to current permanent credits. On the supply side, this would mean low near-term revenue.

There is however the possibility that suppliers will be able to 're-rent' the same sink in the future, providing a continuing (though uncertain) stream of income. Whether the project sponsor can sell upfront a stream of two or three temporary credits instead of one depends on the credibility of his claim that the project will remain permanent over that period of time. Assuming carbon prices remain flat during the first three commitment periods, and using again the 6% risk-free discount rate, we have seen that one temporary credit might be worth 25% of a permanent one. But two sequential temporary credits (10 year conservation) are worth 44% of a permanent one, and three (15 years conservation) are worth 58% of a permanent one. That duration remains in the range of what a typical forestry projects need to provide anyway.

Lower prices for temporary credits are discouraging for many kinds of forestation projects. These typically require large up-front investments in planting, and slow carbon accumulation during the first years of growth. Low carbon payments further decrease the financial attractiveness of these projects. In fact, estimates of the marginal sequestration cost curves for the U.S. (Lubowski et *al.*, 2002) suggest that—at low carbon prices—the elasticity of volume sequestered to carbon prices is very high.

Less affected are some types of biosequestration not currently creditable under Kyoto. Deforestation prevention, for instance, may in some cases not require large up-front investments and can immediately prevent significant emissions. Abandonment to regrowth of pasture or of secondary vegetation may have similar characteristics.

Geological carbon sequestration may be an intermediate case, with high upfront costs but immediate results in emission reductions.

4. An Alternative to Temporary Credits

Our analysis suggests that temporary credits could sell at a steep discount relative to permanent credits. Moreover, the better the perceived prospects for increasingly tight limits on carbon emissions, the lower the value attached to temporary credits.

This is a somewhat perverse result, because some 'temporary' sequestration projects are likely, in fact, to be quasi-permanent. For instance, some natural forests may be under only temporary pressure for conversion to agriculture—pressure that will ease in the course of economic development as urbanization increases and pulls farmers away from marginal lands. Some planted forests may generate self-reinforcing financial and social incentives for their indefinite maintenance. For instance, a community-run forest in the Val di Fiemme, Italy, has been sustainably managed since 1111 (Jeanrenaud, 2001). Some wood products may enjoy long useful lives of decades or centuries. And some geological formations may sequester injected CO_2 for centuries without physical leakage.

While none of these sequestration projects are perfectly secure, arguably each of them has a good chance of enduring for fifty or a hundred years—long enough to bridge the gap to an era when abatement of permanent emissions is relatively inexpensive. Thus a portfolio of such projects, carefully screened and engineered, may arguably retain 80% or 90% of the carbon it contains. This suggests an *ex-ante* risk discounting approach for assuring claims for permanent credits based on sequestration projects.

The approach would be to pre-certify sequestration projects based on their expected half-life, or the proportion of the sink expected to be in place after 60 or 80 years. The project's carbon sequestration 'output' would be reduced by the proportion expected to be lost. That is, the project would be awarded partial credits based on *ex ante* risk assessment. This entails lower overhead costs than an approach based on perpetual monitoring of the status of portfolios of temporary credits.

How difficult would it be to make the *ex ante* assessment? For many project types, there may be ample historical experience with analogous projects or processes. For instance, there may be historical data on the longevity and integrity of forest plantations, wood products, and parks.

Can certifiers be trusted to be honest? In this respect, the task is no different than baseline certification under the CDM. The certifier's baseline decision has direct financial bearing on the project's profitability, and the integrity of the system requires institutions to maintain the integrity of the certification process.

What if the certifiers turn out to be wrong? Again there is an analogy with baseline-setting. It is possible that baselines are systematically set wrong. But except in the very special case where there happens to be good "control group" for the project, we will simply never know if the baselines were wrong. For *ex ante* risk discounting we will know, eventually. If risks are estimated conservatively—as seems prudent—then the climatic benefit will be greater than expected. The global, long-term risk of being systematically wrong needs to be balanced against the global long-term risk of failing to utilize mechanisms that enhance the world's ability to mitigate climate change.

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References

Bailey, Elizabeth, 1998. *Intertemporal Pricing of Sulfur Dioxide Allowances*. MIT Center for Energy and Environmental Policy Research, Cambridge.

Jeanrenaud, Sally. 2001 *Communities and Forest Management in Western Europe*. Gland: IUCN.

Locatelli, Bruno and Lucio, Pedroni, 2003. *Accounting methods for carbon credits: impacts on the minimum size of CDM forestry projects*. Global Change Group, CATIE, Turrialba.

Lubowski, Ruben, Andrew J. Plantinga, and Robert N. Stavins, 2002. Econometric estimation of the national carbon sequestration supply function. Communication to the *Forestry and Agriculture Greenhouse Gas Modeling Forum*, Sheperdestown, 8-11 October.

Schennach, Susan, 2000. "The Economics of Pollution Permit Banking in the Context of Title IV of the 1990 Clean Air Act Amendments." *Journal of Environmental Economics and Management* **40,** 189-210.

Sedjo, Roger and Gregg, Marland, 2003. Inter-trading Permanent Emissions Credits and Rented Temporary Carbon Emissions Offsets: Some Issues and Alternatives. Submitted to *Climate Policy*.

UN Framework Convention on Climate Change (UNFCCC), 2000. *Paper 5: Colombia, Land Use, Land-Use Change and Forestry projects in the CDM: expiring CERs, a proposal to addressing the permanence issues*. In: FCCC/SBSTA/2000/Misc.8, pp.23-26.

Watson, Robert, et *al.* (Ed.), 2000. *Land Use, Land-Use Change, and Forestry*, Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

Figure 1: SO_2 allowance prices (spot and 7-year forward), in current U.S.$ (Source: EPA).

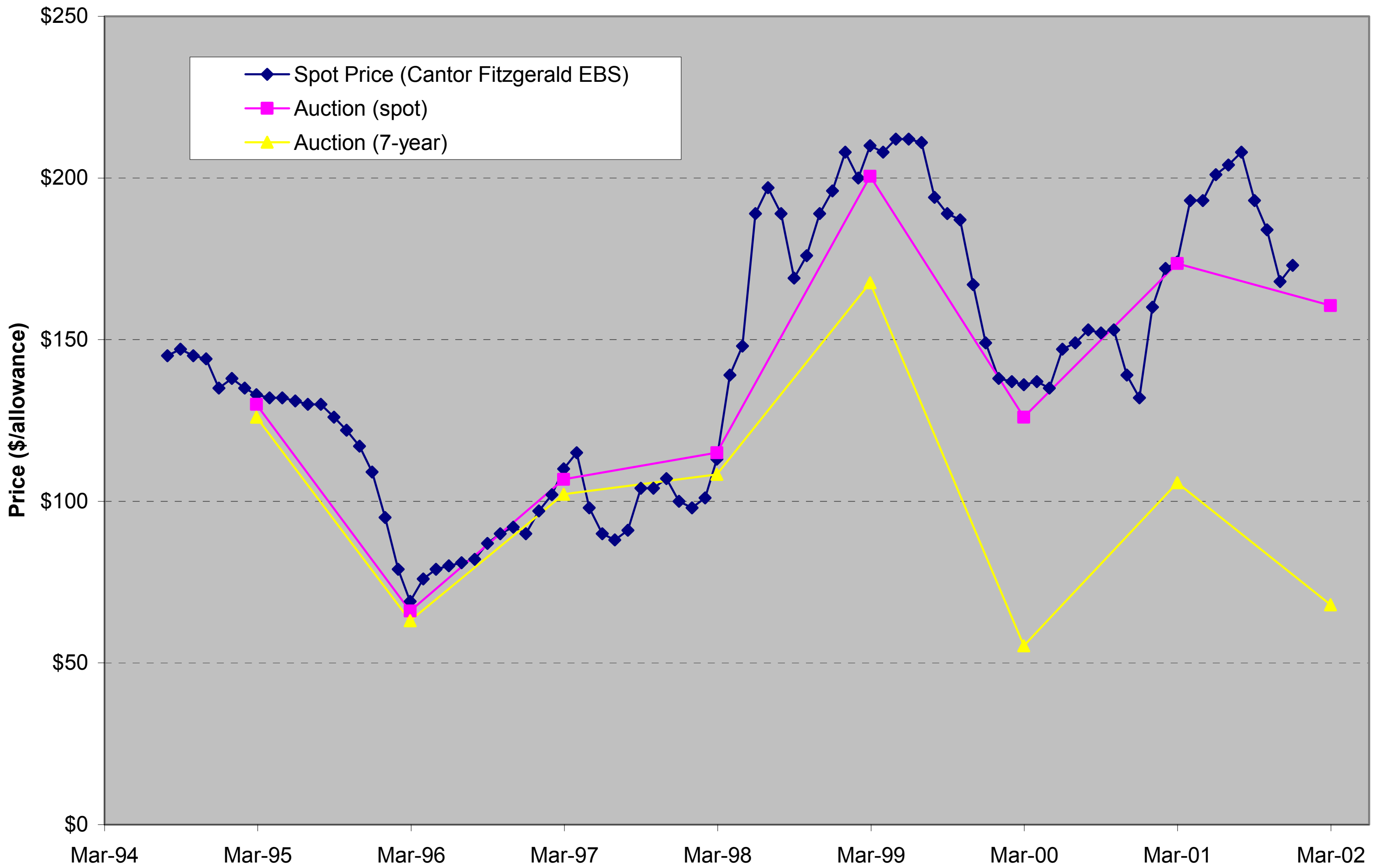

Table 1: P_{temp} for different set of expectations about $P_{2,2}$ (scenarios a to i), and different discount rates.

Case	$\mathbf{P_{1,1}}$	**Probability that $\mathbf{P_{2,2}}$ be**					$\mathbf{P_{temp}}$ Assuming discount rate of		
		\$0	**\$10**	**\$13.4**	**\$20**	**\$50**	3%	6%	10%
a	\$10	100%	0%	0%	0%	0%	\$10.0	\$10.0	\$10.0
b	\$10	0%	100%	0%	0%	0%	\$1.4	\$2.5	\$3.8
c	\$10	0%	0%	100%	0%	0%	<0	\$0	\$1.7
d	\$10	0%	0%	0%	100%	0%	<0	<0	<0
e	\$10	80%	5%	5%	5%	5%	\$6.0	\$6.5	\$7.1
f	\$10	5%	80%	5%	5%	5%	<0	\$0.9	\$2.4
g	\$10	5%	5%	80%	5%	5%	<0	<0	\$0.9
h	\$10	5%	5%	5%	80%	5%	<0	<0	<0
i	\$10	5%	5%	5%	5%	80%	<0	<0	<0